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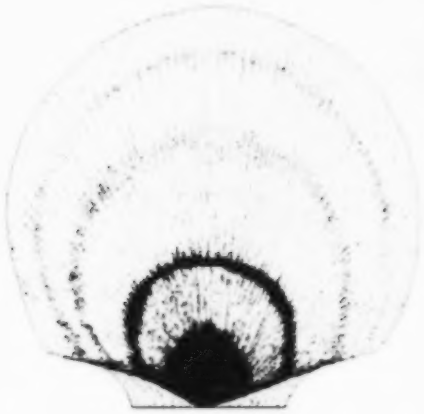
Maritimes Region
Canadian Science Advisory Secretariat
Science Advisory Report 2008/045

ASSESSMENT OF GEORGES BANK SCALLOPS (*PLACOPECTEN MAGELLANICUS*)



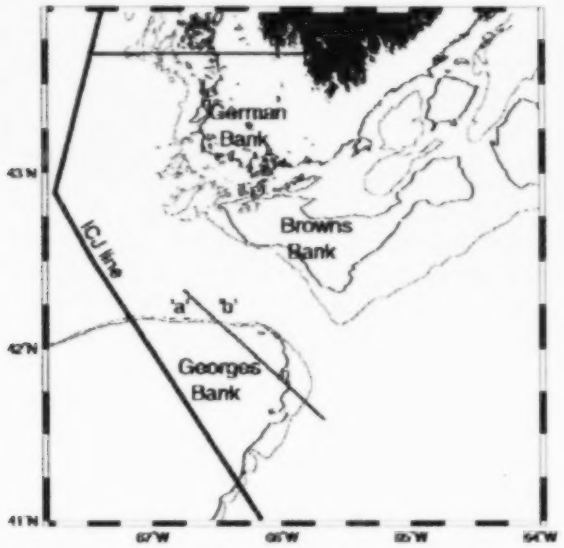


Figure 1: Location of Georges Bank 'a' and 'b'.

Context

The sea scallop, Placopecten magellanicus, is found only in the Northwest Atlantic, from Cape Hatteras to Labrador. Scallops are aggregated in patches and harvestable concentrations are called beds. Major areas of offshore fishing activity are Georges Bank, the Eastern Scotian Shelf (Banquereau, Middle Bank, Sable and Western banks), Browns Bank, German Bank, and St. Pierre Bank (south of Newfoundland). Scallops prefer a sandy, gravel bottom and occur in depths of 35 to 120m on the offshore banks.

The offshore scallop fleet consists of wetfish vessels and freezer trawlers. Generally, these vessels simultaneously fish two New Bedford offshore rakes, 4 to 6.1m width, with one on each side of the vessel.

Annual assessments of the status of the offshore scallop resource take into account the annual survey findings, meat size distribution in the catch, and fishery performance. The management of the main scallop fishery on Georges Bank refers to Zone 'a'. Georges Bank Zone 'b' is a marginal growth area for scallops and has a separate management plan. The assessment and advice presented in this document is for Georges Bank Zone 'a' only, some elements of the fishery in Zone 'b' are also presented for historical purposes.

In support of management of the Georges Bank 2008 scallop fishery, a meeting of the Regional Advisory Process was held 5 May 2008 at the Bedford Institute of Oceanography, in Dartmouth, N.S. to: (1) assess the status of the resource; (2) provide harvest advice for the 2008 fishery; and (3) document by-catch in the fishery for as many previous years as possible. Participants included DFO scientists, fishery managers, and representatives of the industry.

SUMMARY

- The 2007 total allowable catch (TAC) was 4000 t for Zone 'a' and 400 t for Zone 'b'. Total reported landings were 4000 t for Zone 'a' and 401 t for Zone 'b'.

- The offshore scallop fleet fished primarily fresh scallop products until 2002, when freezer trawlers were incorporated into the fleet. In the first year of fishing the freezer trawlers landed nearly 12% of the TAC. In 2007, the freezer trawlers landed 68% (2739 t) of the catches from Zone 'a', 57% (1571 t) of these landings came from within the voluntary closure area. The freezer trawlers also landed 55% (220 t) of the catches from Zone 'b'.

- Commercial catch rates of the wetfish fleet reached historically high levels during 2000 to 2002, declined to near average levels between 2003 and 2006, and in 2007 are the third highest in the series. Freezer trawler catch rates increased dramatically between 2006 and 2007 and are at the highest level since these vessels began fishing in 2002.

- Discards of yellowtail flounder decreased sharply from 565 t in 2006 to 105 t in 2007, while discards of cod increased from 87 t in 2005 to 124 t in 2007. Discards of haddock declined from 67 t in 2006 to 61 t in 2007. Total fishing effort during this period peaked at 36,992 hours in 2006 and declined by more than half to 16,614 hours in 2007.

- Survey catch rates in Zone 'a' for pre-recruits, recruits, and commercial size scallops peaked between 1998 and 2001. All three indices were at or above their respective long-term median values in 2007.

- The 2008 interim TAC is 5000 t and a final TAC between 5500 and 6500 t could be supported based on evidence from the survey and commercial catch data showing a recent steady increase in the stock and above average incoming recruitment.

- A potential lack of proportionality between the commercial catch rate index and stock biomass, arising from changes in fishing practices, along with a lack of recent ageing data are important sources of uncertainty in this assessment. The cohort analysis used in previous assessments of this stock was deemed inadequate due to a poor fit to the data in recent years and to projections that were not consistent with our understanding of the resource.

BACKGROUND

Species Biology

Scallops may reach sexual maturity as early as Age 2 and have separate sexes. The female gonad is red in colour and the male gonad is creamy white. The major spawning period is from August to October; eggs and sperm are released into the sea and fertilization is external. Fertilized eggs develop into the larval stage (veliger) in a few days, and will continue to develop while swimming in the water column for 30 to 60 days before settlement to the bottom. Newly settled larvae undergo a series of morphological changes before becoming a juvenile scallop.

Scallop growth is estimated from the position of annual rings on the shell. The growth rates vary from one fishing area to another and are influenced by season, depth, and temperature.

Fishery

Georges Bank is one of the main sea scallop stocks fished by the offshore scallop fleet. Since 1986, the offshore scallop fleet has fished Georges Bank year round under an Enterprise Allocation management regime. Prior to 1998, this area was managed as one unit, but since then it has been managed as two zones. Zone 'a' is the traditional scallop fishing ground and a more productive area than Zone 'b', which is marginal scallop habitat (Figure 1, Table 1).

Table 1. Canadian landings of sea scallop meats from Georges Bank and total allowable catch (TAC), in metric tons. Since 1998, Georges Bank has been divided into zones 'a' and 'b'.

Year	Catch (t)	TAC (t)
1981	7612	--
1982	3918	--
1983	2418	--
1984	1945	--
1985	3812	--
1986	4900	4300
1987	6793	6850
1988	4336	5400
1989	4676	4700
1990	5218	5200
1991	5805	5800
1992	6151	6200
1993	6183	6200
1994	5003	5000
1995	1984	2000
1996	2996	3000
1997	4259	4250

Year	Catch (t)		TAC (t)	
	Zone 'a'	Zone 'b'	Zone 'a'	Zone 'b'
1998	3191	800	3200	800
1999	2503	1196	2500	1200
2000	6212	601	6200	600
2001	6480	395	6500	400
2002	6469	192	6500	200
2003	5985	199	6000	200
2004	3518	200	3500	200
2005	2484	201	2500	200
2006	3932	162	4000	200
2007	4000	401	4000	400

A TAC and a meat count of 33 meats per 500 grams are used to manage Georges Bank Zone 'a'. Until 2008, Georges Bank Zone 'b' was managed with a meat count of 40 meats per 500 g and a rolling TAC allocated in 200 t increments for a specified fishing period (typically 6 weeks). As of 1 January 2008, Georges Bank Zone 'b' is managed with a conventional TAC and a meat count of 40 meats per 500 g.

In 2004, a strong pulse of juvenile scallops (Age 2) was observed in the research survey, mainly on the northern edge of Georges Bank Zone 'a'. Following the analysis of the survey data, the offshore scallop Industry implemented a voluntary closure of 95 km^2 around one juvenile aggregation. This industry initiative was in place for two years to improve scallop yield. The industry removed the closure in 2007.

Based upon preliminary analysis of the 2007 fishery data and the annual stock survey data, an interim TAC of 5000 t was set for the 2008 Georges Bank Zone 'a' fishery. As well, two new voluntary closures were established by the offshore scallop industry.

The 2007 TAC was 4000 t for Zone 'a', the same as the 2006 TAC, and 400 t for Zone 'b', a 200 t increase from 2006. Total reported landings were 4000 t for Zone 'a' and 401 t for Zone 'b' (Table 1).

In 2002, there were 26 wetfish vessels and 3 freezer trawlers operating. The number of wetfish vessels has declined since then, and in 2007 there were 12 wetfish and 6 freezer trawler vessels fishing at least a portion of the season. The offshore scallop fleet fished primarily fresh scallop products until 2002, when freezer trawlers were incorporated into the fleet. In the first year of fishing, the freezer trawlers landed 775 t or 12% of the total landings. In 2007, the freezer trawlers landed 2739 t or 68% of the total landings from Zone 'a' and 221 t or 55% of the total landings from Zone 'b', compared to 65% and 0% of 2006 landings in 'a' and 'b', respectively.

The wetfish fleet catch rates reached historically high levels between 2000 and 2002, declined to median levels from 2003 to 2006 and in 2007 rose to the third highest level observed since 1981. The freezer trawler catch rates increased dramatically from 2006 to 2007, primarily due to concentration of effort in the 2004-2006 voluntary closure area, and are now at the highest level observed (Figure 2).

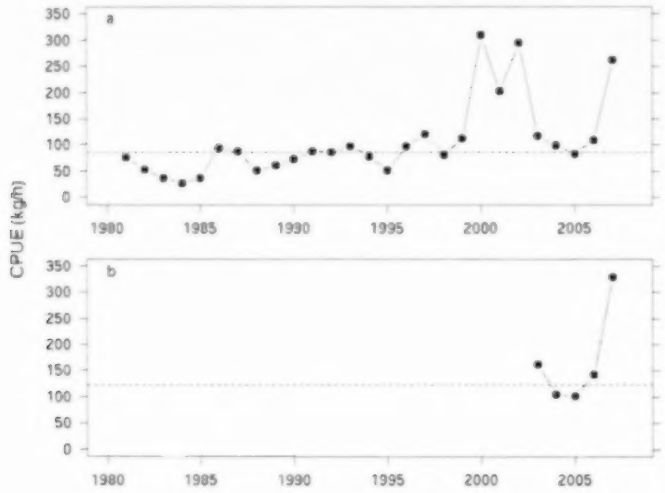


Figure 2. Annual unstandardized catch per unit effort (CPUE) indices (kg/h) for the (a) wetfish and (b) freezer trawler fleets on Georges Bank zones 'a' and 'b'. The dashed lines are (a) the 26-year median value for the wetfish fleet and (b) the 4-year median value for the freezer trawler fleet.

In 2007, the wetfish fleet directed 25% of their total fishing effort to the voluntary closure area, yielding 366 t, or 29% of their total landings. Catch rates on average were 17% higher within the voluntary closure area compared to the rest of Georges Bank Zone 'a'. The freezer trawler fleet directed 54% of their total fishing effort to the voluntary closure area, yielding 1571 t, or 57% of their total landings. Catch rates on average were 13% higher with the voluntary closure area

The fishery landed larger meats in 2007 (21 g mode) than in 2006 (17 g mode) (Figure 3). The meat weight mode in the 2007 catch was 1 g larger than that of the long-term mean distribution (20 g), but meats greater than 22 g were landed less frequently in 2007.

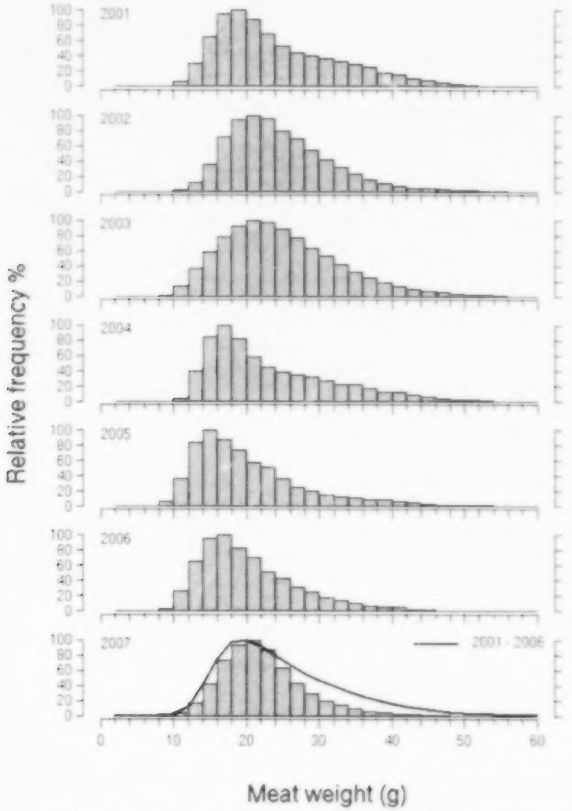


Figure 3. Meat weight distributions by 2-g increments sampled from Georges Bank Zone 'a' landings (2000 to 2007). The solid line (bottom panel) is the 6-year mean distribution.

By-catch

Discards in the scallop fishery on Georges Bank are recorded by independent observers. One scallop trip per month has been observed since 2005 and this coverage was increased to two trips per month in July 2007. Discards from observed trips were prorated to the entire scallop fleet via the observed discard rate (kg/h) (Gavaris, et al. 2007). Discards of all identifiable species were recorded, but only three commercial groundfish species, yellowtail flounder, cod, and haddock are reported here.

Estimated discards of yellowtail flounder increased from 255 t in 2005 to 565 t in 2006 and then declined sharply, due to industry-implemented changes in fishing practices, to 105 t in 2007 (Table 2). Estimated discards of cod increased in all three years from 87 t in 2005 to 124 t in 2007. Estimated discards of haddock were highest at 67 t in 2006 and declined to 61 t in 2007. Fishing effort during this period peaked at 36,992 h in 2006 and declined by more than half to 16,614 h in 2007.

Table 2. Estimated discards of yellowtail flounder (ytf), cod, and haddock (had) caught as by-catch in the scallop fishery on Georges Bank zones 'a' and 'b' during the years 2005 – 2007.

Year	Observed Effort (h)	Total Effort (h)	Species	Total Estimated Discards (t)
2005	2005	31,681	yellowtail flounder	**255**
			cod	**87**
			haddock	**50**
2006	2238	36,992	yellowtail flounder	**565**
			cod	**117**
			haddock	**67**
2007	1726	16,614	yellowtail flounder	**105**
			cod	**124**
			haddock	**61**

ASSESSMENT

Stock Trends and Current Status

There is a joint DFO–Industry survey that takes place annually on Georges Bank, covering both zones, but this assessment is only conducted on data from Zone 'a'. Information is gathered to assess the abundance and composition of the scallop stock. Meat weight data is collected from all of the offshore scallop landings through a port-sampling program. These data, in combination with the annual fishery performance data, are used to produce commercial biomass estimates and provide potential exploitation scenarios to Fisheries and Aquaculture Management Branch.

Survey catch rates in Zone 'a' for pre-recruits, recruits, and commercial size scallops peaked between 1998 and 2001. All three indices were at or above their respective long-term median values in 2007. The mean number per tow of pre-recruit scallops (< 75 mm shell height) increased in 2007 and is now above the long-term median value (Figure 4). This is evident in the shell height distribution for 2007 that shows two cohorts of pre-recruit size scallops (Figure 5). The older cohort (at 60 mm) was not evident in the 2006 survey. The younger cohort (10 - 15 mm) are likely 1 year old scallops that are infrequently captured in the survey, perhaps indicating higher than average spawning and/or settlement success in 2006. The highest density of pre-recruits occurred along the north western edge of Zone 'a' (Figure 6a). High densities were also found on the eastern portion of Zone 'b' (Figure 6a).

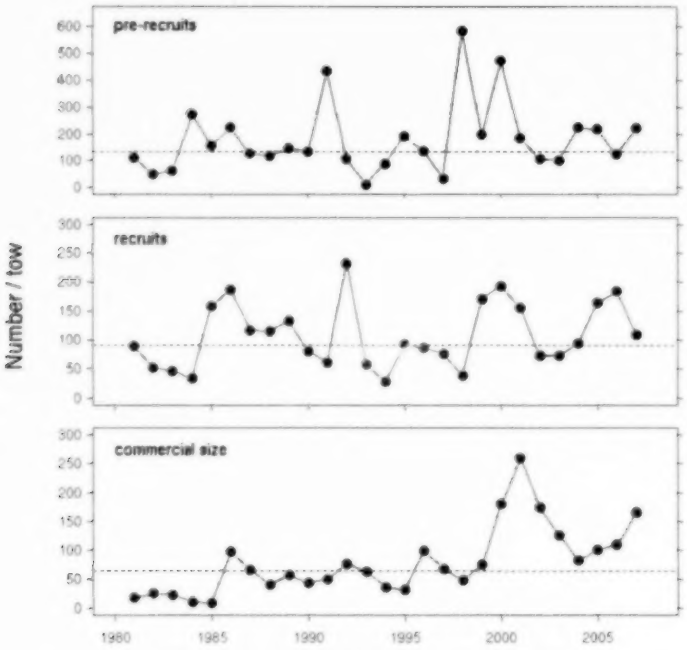


Figure 4. Survey abundance index (mean number/tow) of pre-recruit (< 75 mm shell height), recruit (75-99 mm shell height), and commercial size (>= 100 mm shell height) scallops. The dashed lines are the 26-year median value for each series.

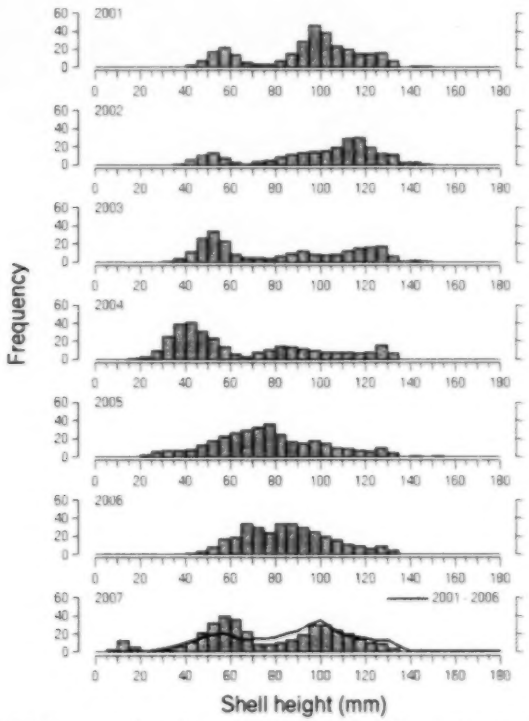


Figure 5. Scallop shell height frequencies (mean number/tow) from the Georges Bank Zone 'a' survey. The solid line (bottom panel) is the 6-year mean.

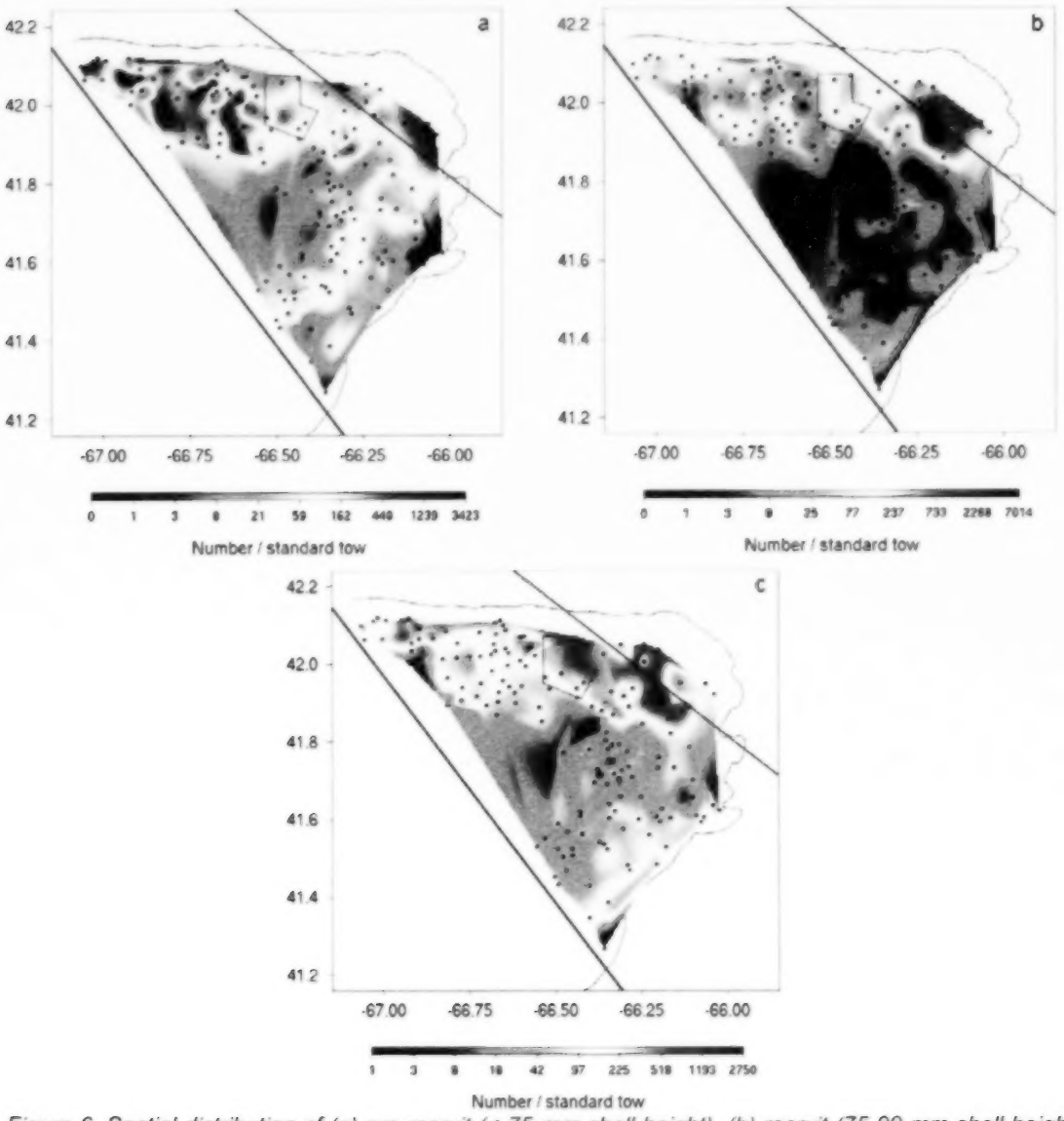


Figure 6. Spatial distribution of (a) pre-recruit (< 75 mm shell height), (b) recruit (75-99 mm shell height), and (c) commercial size (>= 100 mm shell height) scallop catches from the 2007 survey (log scale). Tow positions are indicated. Industry chose to open the voluntary closure area (polygon in upper middle region) in 2007.

The index of recruiting scallops (75-99 mm shell height) has fluctuated above and below the long-term median since 1995 and in 2007 declined to a level just above the long-term median value (Figure 4). The shell height distribution for 2007 also shows this change relative to 2006 (Figure 5). The highest densities of recruiting scallops were found straddling the boundary between zones 'a' and 'b' (Figure 6b). Moderately high densities were also found in the northern portion of the 2004 - 2006 voluntary closure area.

The mean number per tow of commercial sized (≥ 100 mm shell height) scallops reached a long-term high in 2001, declined until 2004 and has increased since then (Figure 4). The series

has been above the long-term median since 1999. High densities of commercial sized scallops were found all along the northern edge of zones 'a' and into 'b' (Figure 6c). The 2004-2006 closure area still had moderately high densities of commercial sized scallops, despite high levels of exploitation in 2007.

A cohort analysis with a quarterly time-step was used to estimate age-structured population abundance, biomass, and fishing mortality based on the survey index, commercial catch rates, and age composition in the catch. It also provided the 2008 stock projections and catch scenarios. The analysis calculates cohort sizes backward in time from terminal years and ages, which, in turn, are estimated by tuning to the survey and commercial catch rate data.

Two models were presented at the assessment meeting. The first model (Model 1) was tuned to the survey and commercial catch rate indices and was similar to what had been presented in the past. A second model (Model 2) was presented, which was tuned only to the survey index. Neither of these was considered to be adequate for the provision of science advice in 2008. The first model did not fit the data in recent years (Figure 7); whereas, the second model was a better fit to the recent data (Figure 8), but provided yields (projections) that were not consistent with our understanding of the resource.

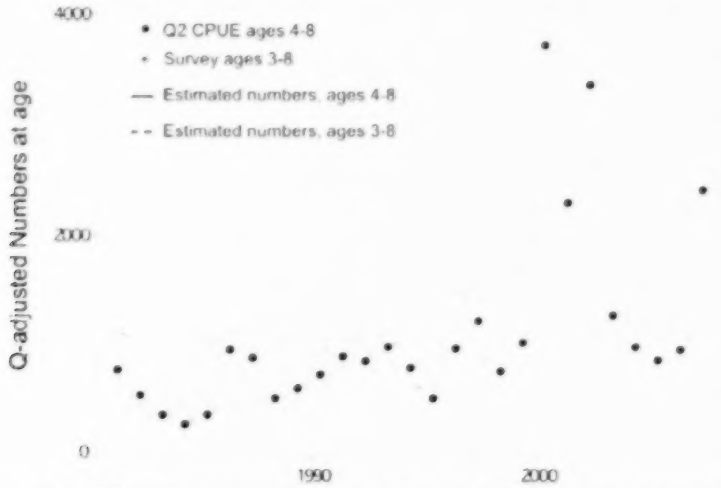


Figure 7. Fit of Model 1 to 2nd quarter commercial CPUE (ages 4-8) index and survey index (ages 3-8).

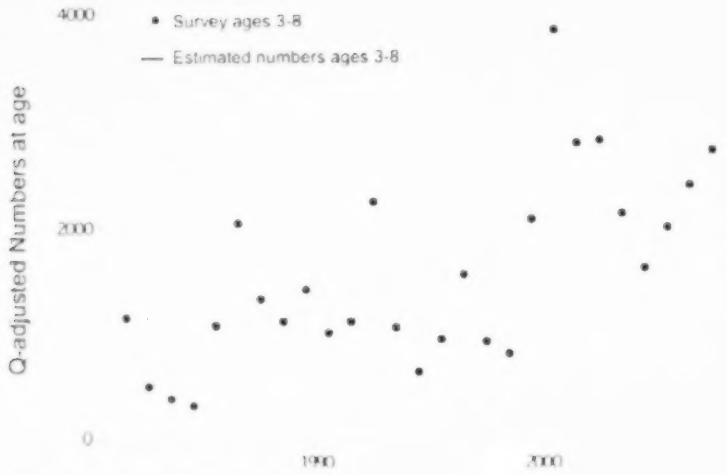


Figure 8. Fit of Model 2 to survey index (ages 3-8).

Assessment advice was based upon interpretation of commercial catch data, the survey index, and shell height frequencies from the survey. The survey index was used to define stock status relative to previous years and to examine responses to fishery removals defined by the commercial catch data. Patterns in the shell frequency data were used to evaluate the current and likely future status of recruitment to the fishery.

Sources of Uncertainty

The cohort analysis does not capture well the rapid changes in stock age structure that are observed; for example, after large recruitment events. This shortcoming suggests that, on average, the biomass estimates are conservative. This is evident during the period 2003–2007 when Model 1 appears to fit only to the commercial catch rate index, but does not capture the rapid increase in 2007 (Figure 7). Although Model 2 generally was a better fit to the survey index, it appears to estimate a more rapid increase in abundance between 2003 and 2007 than suggested by the survey index (Figure 8).

Model predictions depend, in part, on how well year class strengths are estimated. In particular, estimating year class strength at Age 2 (juvenile) is challenging because these scallops are not consistently observed in the survey due to their relatively low catchability and relatively high spatial aggregation. These catchability and aggregation issues will reduce the precision of abundance and distribution estimates.

There is spatial heterogeneity in the distribution of age groups. The fishing fleet targets particular scallop size classes that can result in spatial aggregation of fishing effort. This aggregation suggests that the commercial catch rate index may not be proportional to abundance or biomass. This non-proportionality could be exacerbated in the future as fishing effort becomes more aggregated in voluntary closure areas.

A lack of recent ageing data for Georges Bank scallops is a serious concern. For example, biased estimates of growth rates will lead to over-estimation of the strength of weak cohorts. Georges Bank scallops are difficult to age reliably using standard techniques; therefore, it would be beneficial to consider biomass dynamic or length-based models for future assessments, at least until more reliable ageing techniques can be adopted.

CONCLUSIONS AND ADVICE

Advice is based on interpretation of the survey index and commercial catch data, and not on a quantitative assessment model.

Abundance of commercial sized scallops has been above the long-term median since 1999 and is currently at the fourth highest level observed in the survey index since 1981 (Figure 4). In addition, there is evidence of two above average cohorts that will recruit to the fishery during the next 3 years (Figure 5). Commercial catches were at or above 6000 t between 2000 and 2003 (Table 1) when the stock was at peak abundance, and although the stock had declined to near the long-term average by 2004, recovery has been steady since then (Figure 5). There is no evidence in the recent past however, to indicate how the stock would respond to removals above 6500 t. The 2008 interim TAC is 5000 t and a final TAC between 5500 and 6500 t could be supported given the recent steady increase in the stock and the evidence of above average incoming recruitment. New voluntary closures implemented by Industry around two large aggregations of juvenile scallops reduces the risk of recruitment failure.

SOURCES OF INFORMATION

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